

Status of Claims

Claims 1, 3, 4, 6, 8-14, and 17-33 are pending in the application. Claims 1-20 were originally presented in the application. Claims 2, 5, 7, 15, and 16 were cancelled without prejudice, and new claims 21-33 were submitted in a response to office action mailed by Applicants on August 20, 2001. The rejection of claims 1, 3, 4, 6, 8-14, and 17-33 based on the cited references is appealed. The pending claims are shown in the attached Appendix.

Status of Amendments

The claims in Appendix A include amendments presented in a response to Final office action mailed by Applicants on May 1, 2002, which will be entered by the Examiner upon submission of this brief. A supplemental information disclosure statement was submitted by the Applicants on August 16, 2002, as a result of a communication from the Austrian patent office dated June 20, 2002.

Summary of Invention

The presence of native oxides and other contaminants within a small feature 11 typically results in voids 15 in the metal deposited in the features as the native oxides and other contaminants promote uneven distribution of the depositing metal. (See, Figure 1.) The native oxide typically forms as a result of exposing the exposed film layer/substrate to oxygen. (See, specification at page 2, lines 27-30.) The other contaminants within the features typically forms as a result of sputtered material from an oxide over-etch, residual photoresist from a stripping process, leftover hydrocarbon or fluorinated hydrocarbon polymers from a previous oxide etch step, or re-deposited material from a pre-clean sputter etch process. (See, specification at page 2, line 33 through page 3, line 2.) The native oxide and other contaminants create regions on the substrate, which interfere with film formation by creating regions where film growth is stunted. (See, specification at page 3, lines 2-4.)

Pre-cleaning of features using sputter etch processes is effective for reducing contaminants in large features or in small features having aspect ratios smaller than about 4:1. However, sputter etch processes can damage silicon layers by physical

bombardment, sputter deposition of Si/SiO₂ onto sidewalls of the features, and sputter deposition of metal sub-layers, such as aluminum, onto sidewalls of the features. For larger features, the sputter etch processes typically reduce the amount of contaminants within the features to acceptable levels. For small features having larger aspect ratios, sputter etch processes have not been as effective in removing contaminants within the features, thereby compromising the performance of the devices which are formed. (See, specification at page 3, lines 15-23.)

The present invention is an improvement over *Zhao et al.*, (U.S. Patent No. 5,660,682), which illustrates an attempt to combine etching and reactive cleaning of patterned dielectric layers using a plasma comprising hydrogen and argon. The argon etches deposits from apertures and the hydrogen reacts with remaining deposits to form gaseous byproducts. The combination of etching and cleaning does improve subsequent deposition of metals, however, the combined plasma processing does not prevent formation of voids in subsequent metal layers. Therefore, there remained a need for a method to improve deposition of metal layers on a patterned dielectric layer, especially apertures such as vias and trenches having an aspect ratio greater than about 1.0. (See, specification at page 3, lines 21-28.)

Accordingly, the invention provides a process for cleaning a patterned dielectric layer in a processing chamber using a first plasma 212 consisting essentially of argon. The patterned dielectric layer is then further cleaned in the processing chamber with a second plasma 215 consisting essentially of hydrogen and helium. (See, specification at page 11, lines 28-33 and at Figure 3). A metal layer 225 is then deposited after exposing the dielectric layer to the first plasma 212 and the second plasma 212. (See, specification at page 10, lines 13-17 and at Figure 3.)

Issues Presented

1. Whether the Examiner erred in rejecting claims 1, 3, 4, 6, 8-14, and 17-33 under U.S.C. § 103(a) as being unpatentable over *Yoo et al.* (U.S. Patent No. 5,203,957) in view of *Zhao et al.* (U.S. Patent No. 5,660,682).

Grouping of Claims

Claims 1, 3, 4, 6, 8-14, and 17-33 stand or fall together for all arguments presented by Applicants.

ARGUMENT

1. THE EXAMINER ERRED IN REJECTING CLAIMS 1, 3, 4, 6, 8-14, and 17-33 BECAUSE THE REFERENCES DO NOT MOTIVATE OR SUGGEST A TWO STEP CLEANING PROCESS COMPRISING A FIRST PLASMA OF ARGON AND A SECOND PLASMA OF HELIUM AND HYDROGEN.

Claims 1, 3, 4, 6, 8-14, and 17-33 stand rejected under U.S.C. § 103(a) being unpatentable over *Yoo et al.* (U.S. Patent No. 5,203,957) in view of *Zhao et al.* (U.S. Patent No. 5,660,682). The Examiner states that *Yoo et al.* teaches two plasma etching steps consisting of: (1) a first plasma of argon and (2) a second plasma of helium and a reactive gas such as CF₄ or CF₃H. The Examiner states that *Zhao et al.* teaches an argon plus hydrogen plasma. The Examiner, therefore, asserts that it would have been obvious to one of ordinary skill in the art that "hydrogen was a reactive gas that could have been used equivalently in the process of *Yoo et al.* ... because it was shown to produce like effects in analogous situations and configurations". Furthermore, the Examiner states in the Advisory Action dated May 13, 2002, that *Konenchi* (EP 0849779) and *Subrahmanyam et al.* (WO 99/34424) have teachings similar to *Zhao et al.* and therefore, "confirm the logic of the combination" (referring to the combination of *Yoo et al.* in view of *Zhao et al.*)

Applicants respectfully traverse the rejection on grounds that the Examiner has not established a case of *prima facie* obviousness. The mere recitation of a combination of references does not amount to particularly identifying a suggestion, teaching, or a motivation to combine the references. (See, M.P.E.P. § 2143.) The teaching or suggestion to make the claimed invention and the reasonable expectation of success must both be found in the prior art, not in the applicants' disclosure. See M.P.E.P. § 2143, citing *In re Vaeck*, 947 F.2d 488 (Fed. Cir. 1991). Still further, the examiner must *particularly* identify any suggestion, teaching or motivation from within

the references to combine the references. See *In Re Dembiczak*, 50 USPQ2d 1614 (Fed. Cir. 1999).

Here, the Examiner stated that it would have been obvious to use hydrogen "because it was shown to produce like effects in analogous situations and configurations". This motivation to combine the references identified by the Examiner is merely an unsupported conclusion that the combined elements provide an obvious result or "a logical combination". There is no evidence of record to support the Examiner's stated motivation. Unsupported legal conclusions and impermissible hindsight may not provide a proper basis to support a rejection based on *prima facie* obviousness. Moreover, even though references can be combined or modified, the possibility of a combination is not sufficient to establish *prima facie* obviousness. See M.P.E.P. § 2143.01.

Furthermore, "[i]n determining the differences between the prior art and the claims, the question under 35 U.S.C. § 103 is not whether the differences themselves would have been obvious, but whether the claimed invention as a whole would have been obvious." See, M.P.E.P. § 2141.02 citing *Stratoflex, Inc. v. Aeroquip Corp.*, 218 USPQ 871 (Fed. Cir. 1983). *Yoo et al.* teaches an argon sputtering process to smooth corners formed within a feature followed by a "soft-etching" process of a carbon tetrafluoride/helium mixture to decrease contact resistance for a nonsilicided device. (See, *Yoo et al.* at col. 4, line 50 through col. 5, line 13.) *Yoo et al.* also teaches that the soft etching plasma is not needed for silicided devices, which teaches away from a two-step process recited in the present claims. (See, *Yoo et al.* at col. 5, line 60.) *Zhao et al.* discloses removing oxides from a silicon substrate by forming a plasma of argon and hydrogen.

The Examiner has failed to set forth that the references can be combined to motivate or suggest cleaning a patterned dielectric layer in a processing chamber with a first plasma comprising predominantly argon and cleaning the patterned dielectric layer in the processing chamber with a second plasma consisting essentially of hydrogen and helium, as recited in claims 1, 6, 14, 33, and those dependent therefrom. A combination of the references also does not motivate or suggest cleaning the patterned dielectric layer in a processing chamber with an argon plasma and cleaning the patterned

dielectric layer in the processing chamber with a hydrogen plasma, as recited in claim 24 and those dependent therefrom. In fact, none of the references motivate or suggest a step comprising hydrogen and helium as recited in every pending claim. For at least these reasons, Applicants respectfully request withdrawal of the rejection and allowance of the claims.

Conclusion

A combination of the references does not motivate or suggest a first cleaning step comprising an argon plasma and a second cleaning step comprising a hydrogen and helium plasma. A combination of the references also does not motivate or suggest a first cleaning step comprising an argon plasma and a second cleaning step comprising a hydrogen plasma. For at least this reason, Applicants submit that the pending claims are patentable over the references, and respectfully request withdrawal of the rejection.

Respectfully submitted,



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APPENDIX

1. A method for improving metal deposition on a patterned dielectric layer, comprising:
 - a) cleaning the patterned dielectric layer in a processing chamber with a first plasma comprising predominantly argon;
 - b) cleaning the patterned dielectric layer in the processing chamber with a second plasma consisting essentially of hydrogen and helium; and
 - c) depositing a metal on the patterned dielectric layer after exposing the dielectric layer to the first plasma and the second plasma.
3. The method of claim 1, wherein the first plasma consists essentially of argon.
4. The method of claim 1, wherein the second plasma consists essentially of about 5% hydrogen by number of atoms and about 95% helium by number of atoms.
6. A method for improving metal deposition on a patterned dielectric layer on a substrate, comprising:
 - a) cleaning the patterned dielectric layer in a processing chamber with a first plasma comprising predominantly argon, wherein the first plasma is generated by supplying a RF power to a coil surrounding the processing chamber and supplying a RF power to bias a substrate support member supporting the substrate;
 - b) cleaning the patterned dielectric layer in the processing chamber with a second plasma consisting essentially of hydrogen and helium, wherein the second plasma is generated by supplying the RF power to the coil surrounding the processing chamber and supplying the RF power to bias the substrate support member supporting the substrate; and
 - c) depositing a metal layer after exposing the dielectric layer to the first plasma and the second plasma.
8. The method of claim 6, wherein the first plasma consists essentially of argon.

9. The method of claim 6, wherein the second plasma consists essentially of about 5% hydrogen by number of atoms and about 95% helium by number of atoms.
10. The method of claim 6, further comprising depositing a barrier layer prior to depositing the metal layer.
11. The method of claim 6, wherein the RF power supplied to bias *the* substrate support member and generate the second plasma is less than the RF power supplied to bias the substrate support member and generate the first plasma.
12. The method of claim 6, wherein the first plasma is generated with about 300 W of the RF power supplied to the coil and about 300 W of the RF power supplied to bias the substrate support member, and the second plasma is generated with about 450 W of the RF power supplied to the coil and about 10 W of the RF power supplied to bias the substrate support member.
13. The method of claim 6, wherein each of the first plasma and the second plasma are maintained in the processing chamber for about 60 seconds.
14. A method for improving metal deposition on a patterned dielectric layer on a substrate, comprising:
 - a) cleaning the patterned dielectric layer in a processing chamber with a first plasma consisting essentially of argon, wherein the first plasma is generated by supplying a RF power to a coil surrounding the processing chamber and supplying a RF power to bias a substrate support member supporting the substrate;
 - b) cleaning the patterned dielectric layer in the processing chamber with a second plasma consisting essentially of hydrogen and helium, wherein the second plasma is generated by increasing the supply of the RF power to the coil surrounding the processing chamber and reducing the supply of the RF power to bias the substrate support member supporting the substrate;

- c) depositing a barrier layer on the patterned dielectric layer after exposing the dielectric layer to the first plasma and the second plasma; and
- d) depositing a metal on the barrier layer.

17. The method of claim 14, wherein the second plasma consists essentially of about 5% of hydrogen by number of atoms and about 95% of helium by number of atoms.

18. The method of claim 14, wherein the first plasma is generated with about 300 W of the RF power supplied to the coil and about 300 W of the RF power supplied to bias the substrate support member, and the second plasma is generated with about 450 W of the RF power supplied to the coil and about 10 W of the RF power supplied to bias the substrate support member.

19. The method of claim 14, wherein each of the first plasma and the second plasma are maintained in the processing chamber for about 60 seconds.

20. The method of claim 14, wherein the first plasma is generated at about 0.8 mtorr, and the second plasma is generated at about 80 mtorr.

21. The method of claim 1, wherein the patterned dielectric layer comprises one or more features having an aspect ratio greater than 1:1.

22. The method of claim 6, wherein the patterned dielectric layer comprises one or more features having an aspect ratio greater than 1:1.

23. The method of claim 14, wherein the patterned dielectric layer comprises one or more features having an aspect ratio greater than 1:1.

24. A method for improving metal deposition on a patterned dielectric layer, comprising:

- a) cleaning the patterned dielectric layer in a processing chamber with an argon plasma;
 - b) cleaning the patterned dielectric layer in the processing chamber with a hydrogen plasma; and then
 - c) depositing a metal on the patterned dielectric layer.
25. The method of claim 24, wherein the argon plasma consists essentially of argon.
26. The method of claim 24, wherein the argon plasma comprises argon and helium.
27. The method of claim 24, wherein the hydrogen plasma comprises hydrogen and helium.
28. The method of claim 24, wherein the hydrogen plasma comprises about 5% hydrogen by number of atoms and about 95% helium by number of atoms.
29. The method of claim 24, wherein the hydrogen plasma comprises about 5% hydrogen or more by number of atoms.
30. The method of claim 24, wherein the hydrogen plasma comprises about 95% helium or less by number of atoms.
31. The method of claim 24, wherein the argon plasma physically bombards an outer surface of the patterned dielectric layer.
32. The method of claim 31, wherein the hydrogen plasma chemically reacts with the outer surface of the patterned dielectric layer to reduce oxides formed on the outer surface.
33. A method for improving metal deposition on a patterned dielectric layer, comprising:

- a) patterning a dielectric layer in a processing chamber to form one or more features having an aspect ratio greater than 1:1;
- b) cleaning the patterned dielectric layer in the processing chamber with a first plasma comprising predominantly argon;
- c) cleaning the patterned dielectric layer in the processing chamber with a second plasma comprising about 5% hydrogen by number of atoms and 95% helium by number of atoms; and
- d) depositing a metal on the patterned dielectric layer after exposing the dielectric layer to the first plasma and the second plasma.